

Transcatheter Closure of Atrial Septal Defects with Superior-anterior Rim Deficiency Using Amplatzer Septal Occluder

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Background/Purpose: To evaluate the outcome of transcatheter closure of atrial septal defects (ASD) with superior-anterior (SA) rim deficiency using Amplatzer septal occluder (ASO).

Methods: Between June 2003 and March 2007, 84 patients with secundum type ASD attempted transcatheter insertion of ASO in our institution. According to the transesophageal echocardiographic findings, patients were divided into two groups: group A, with deficient SA rim (<3 mm); group B, with sufficient SA rim (≥3 mm). There were 43 children and 41 adults (age range, 2.0–79.4 years; mean age, 22.0 ± 20.2 years). The failure rate, complications and the presence of residual shunt were compared between the two groups.

Results: There were 34 patients in group A and 50 patients in group B. Failure of ASO implantation occurred in six patients, three in each group. One patient had two ASOs implanted for two separate ASDs. Therefore, the study cohort consisted of 78 patients with 79 ASO placed. Among 78 patients with successful implantation, five (6.4%) had persistent small residual shunt during follow-up (range, 1–46 months; mean, 21.6 ± 12.0 months). There was no statistically significant difference between group A and group B in the procedure's failure rate ($p=0.682$), complications ($p=1.0$) and the presence of residual shunt ($p=0.381$) during the follow-up period.

Conclusion: ASD with deficient SA rim is a common variation. Similar to ASD with sufficient rims, transcatheter closure of secundum type ASD is also effective for ASD with SA rim deficiency. [*J Formos Med Assoc* 2007;106(12):986–991]

Key Words: Amplatzer septal occluder, atrial septal defect, superior-anterior rim deficiency

Percutaneous closure of the secundum type of atrial septal defect (ASD) with Amplatzer septal occluder (ASO) is an acceptable alternative to surgical closure. Centrally located ASD is ideally suited for percutaneous closure.^{1–5} However, morphologic variations in ASDs are common whilst

the deficient superior-anterior (SA) rim is the most frequently encountered variation.^{6–9} Recently, despite there being a higher risk of disk impingement on the surrounding cardiac structures, or left atrial disk of ASO prolapse in patients with SA rim deficiency, application of ASO in such cases

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has been described.^{7,8,10} The purpose of this study was to evaluate the outcome of transcatheter closure of ASD with SA rim deficiency using ASO in our institution.

Methods

Between June 2003 and March 2007, 87 patients with secundum type ASD were referred to our institution for transcatheter insertion of ASO (AGA Medical Corp., Golden Valley, MN, USA). The indication for closure was right ventricular volume overload and/or the ratio of pulmonary blood flow and systemic blood flow (Q_p/Q_s ratio) ≥ 1.5 . Three patients were excluded because the ASD diameter was larger than 38 mm as demonstrated on transesophageal echocardiography (TEE). Transcatheter closure of ASD using ASO was attempted in 84 patients. There were 24 males and 60 females. Forty-three patients were children and 41 were adults. The mean age was 22.0 ± 20.2 years (range, 2.0–79.4 years). Mean body weight was 41.1 ± 24.0 kg (range, 8.9–122.0 kg). Forty-seven patients had symptoms, including exercise intolerance ($n=22$), chest pain ($n=13$), palpitation/arrhythmia ($n=10$), poor weight gain ($n=8$), stroke ($n=2$) and syncope ($n=2$).

The procedure was performed under general anesthesia. All patients received prophylactic antibiotic treatment with one dose of cefazolin

(25 mg/kg) given intravenously. Intravenous heparin (100 U/kg) was administered during the intervention. The morphologic characteristics of the defect were evaluated by TEE before ASO closure. Echocardiographic study was performed using the Philips SONOS 7500 system (Philips, Andover, MA, USA). All patients had adequate circumferential rims except the SA aspect. Patients were divided into two groups according to the TEE findings: group A (Figure 1), with SA rim deficiency (< 3 mm); group B (Figure 2), with sufficient SA rim (≥ 3 mm). In our first 35 cases, the size of the ASD was measured by TEE and the cylindrical Amplatzer sizing balloon (AGA Medical Corp.). The size of the ASO was chosen based on the latter with the device size equal to or exceeding by 2–4 mm in diameter. After October 2004, the size of the ASD was measured by TEE without balloon sizing in most of our cases. The measurement of ASD by TEE was modified according to Carcagni and Presbitero's study.¹¹ All patients received aspirin (5 mg/kg/day) for 6 months to prevent thromboembolic complications. Follow-up echocardiographic studies were done on the next day before discharge and at 3, 6 and 12 months after the procedure.

Statistical analysis

Results are expressed as mean \pm standard deviation. Comparison of parameters between the groups was performed with unpaired Student's *t* test,

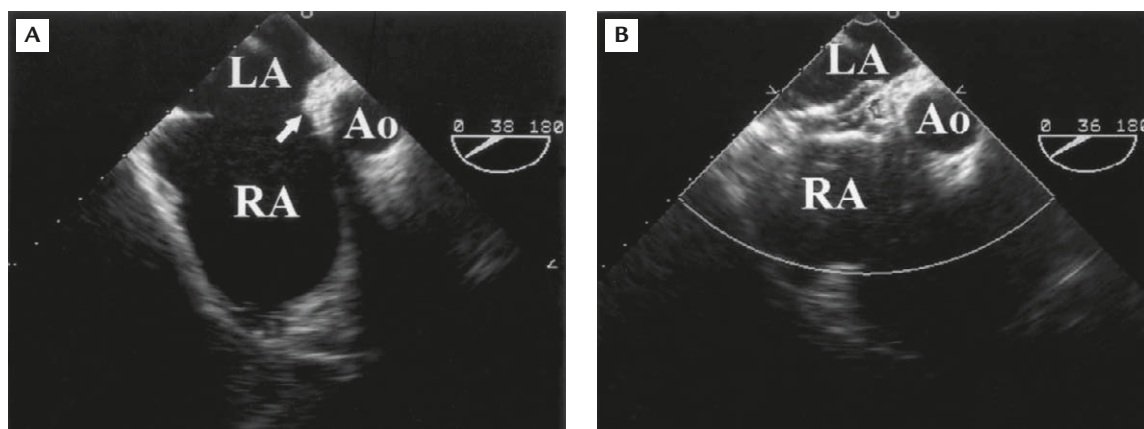


Figure 1. Transesophageal echocardiography shows atrial septal defect with deficient superior-anterior rim (arrow): (A) before and (B) after transcatheter Amplatzer septal occluder implantation. Ao = aorta; LA = left atrium; RA = right atrium.

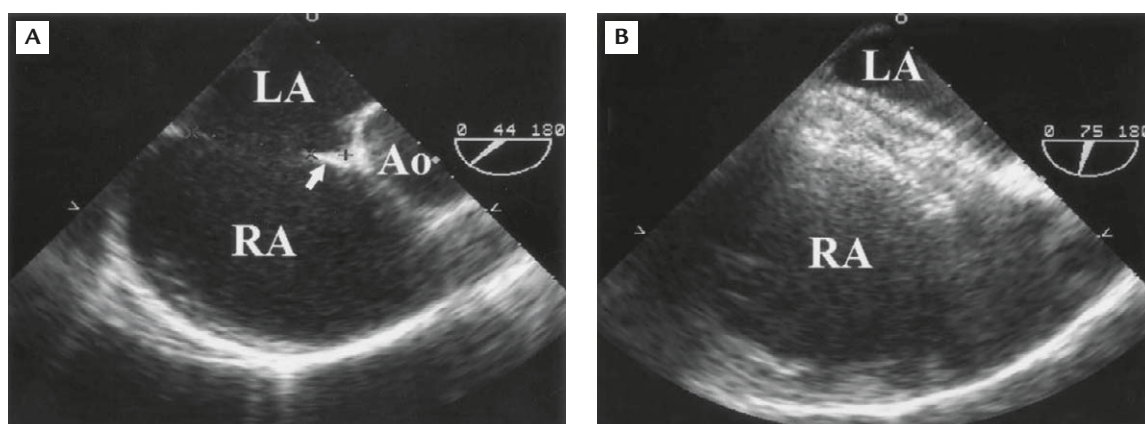


Figure 2. Transesophageal echocardiography shows atrial septal defect with sufficient superior-anterior rim (arrow): (A) before and (B) after transcatheter Amplatzer septal occluder implantation. Ao = aorta; LA = left atrium; RA = right atrium.

Table 1. Clinical characteristics of patients with atrial septal defect

	Group A: deficient SA rim (n = 34)	Group B: sufficient SA rim (n = 50)	p
Age (yr)	21.4 ± 22.3	22.5 ± 18.8	0.817
Sex (F/M)	28/6	32/18	0.068
Body weight (kg)	38.7 ± 26.9	42.7 ± 21.9	0.455
Qp/Qs ratio	2.3 ± 0.8	2.7 ± 1.0	0.092
Mean PAP (mmHg)	19.0 ± 5.7	19.1 ± 7.6	0.958
ASD diameter (mm)	18.4 ± 6.6	20.5 ± 7.7	0.189
Fluoroscopic time (min)	12.0 ± 3.5	10.9 ± 3.7	0.163

SA = superior-anterior; Qp/Qs = pulmonary blood flow/systemic blood flow; PAP = pulmonary artery pressure; ASD = atrial septal defect.

Pearson's χ^2 test or Fisher's exact test. Statistical analyses were performed using SPSS version 9.0 (SPSS Inc., Chicago, IL, USA) for Windows. A value of *p* less than 0.05 was considered to be statistically significant.

Results

There were 34 patients in group A and 50 patients in group B. The demographic and clinical data are summarized in Table 1.

In our first 35 cases, the ASD diameter measured by TEE and balloon sizing was 17.9 ± 7.2 mm and 20.3 ± 8.0 mm, respectively. The diameter measured by balloon sizing was larger than that measured by TEE. However, a discrepancy > 5 mm was found in seven cases in our study. In these

cases, the ASO size was determined by the larger one. In the other 49 cases, the diameter measured by TEE only was 20.9 ± 7.2 mm.

The mean Qp/Qs ratio for all 84 patients was 2.5 ± 0.9 (range, 1.5–5.8), mean pulmonary artery pressure was 19.0 ± 6.9 mmHg (range, 11–55 mmHg), mean ASO size was 22.0 ± 8.2 mm (range, 9–38 mm), and mean fluoroscopic time was 11.4 ± 3.6 minutes (range, 4.7–21.3 minutes). There were no statistically significant differences between groups A and B with regard to age, sex, body weight, Qp/Qs ratio, mean pulmonary artery pressure, ASD diameter, and fluoroscopic time. Seventy-nine ASO devices were successfully implanted in 78 patients, included one patient who received two ASO implantations. ASO implantation failed in six patients, three in each group. The procedure success rate was 92.9%.

Table 2. Outcomes of patients with and without superior-anterior (SA) rim deficiency

	Group A: deficient SA rim (<i>n</i> = 34)	Group B: sufficient SA rim (<i>n</i> = 50)	<i>p</i>
Failure	3	3	0.682
Complication	1	1	1.000
Persistent residual shunt	3	2	0.381

During the procedure, two patients had transient arrhythmia; one had atrial tachycardia and one had complete atrioventricular block. In both cases, the arrhythmia subsided spontaneously. There were no other complications in the study. Twenty (25.6%) patients had small residual interatrial shunt on the next day. Only five patients still had persistent small residual shunt during follow-up (6.4%). The mean duration of follow-up was 21.6 ± 12.0 months (range, 1–46 months). There were no statistically significant differences between groups A and B with regard to the procedure failure rate ($p=0.682$), complications ($p=1.0$) and the presence of residual shunt ($p=0.381$) during follow-up (Table 2).

Discussion

Surgical repair of ASD can be performed successfully with low mortality. However, the morbidities associated with cardiopulmonary bypass, prolonged hospital stay, post-pericardiotomy syndrome, and surgical scarring are considerable.¹² Since the first attempt in 1974 by King and Mills,¹³ transcatheter closure of ASD is now becoming an acceptable alternative to cardiac surgery. Such management is safe and may decrease morbidity, length of hospital stay and cost when compared to surgical closure.^{14–17} The ASO has been well described as an innovative self-centering and self-expanding device that is repositionable and is effective for ASD closure.^{1–4}

The ASO was designed to close ASD with a central waist to occupy the defect and two flat disks to eliminate any residual flow across the septum.⁶ To achieve stable fixation of the ASO and complete

defect closure, and to avoid damage to the nearby structures, it is crucial that there are adequate surrounding rims to serve as the support on which the left and right atrial disks can anchor onto to form a triple-layer sandwich configuration. Since the left atrial disk and right atrial disk differ in radius by 2–3 mm, depending on the diameter of the waist, thin rim <3 mm may not allow sufficient contact of the ASO disks for device stabilization. Furthermore, insufficient ASD rims may lead to compromise of nearby vessels or atrioventricular valves by the disk after ASO implantation.

The atrial septum is surrounded by several important structures. The aortic root is located anterosuperiorly, the mitral valve and tricuspid valve anteroinferiorly, the superior vena cava and right upper pulmonary vein posterosuperiorly and the inferior vena cava posteroinferiorly. SA rim deficiency is common, with reported incidences ranging from 28% to 54%.^{6–10} In the present study, the incidence of SA rim deficiency was 40.5%.

Although ASD repair by transcatheter ASO closure is increasingly gaining acceptance,^{7,8} one of its problems is that the superior aspect of the left atrial disk tends to prolapse across the defect into the right atrium in patients with SA rim deficiency. To overcome this problem, some techniques have been developed, such as using a large curve delivery sheath or deployment of the left atrial disk at the orifice regions of the right or left upper pulmonary vein.^{18,19} In our study, for ASD without rim deficiency, the chosen ASO size was equal to or 1–2 mm larger than the measured ASD diameter. For ASD with deficient SA rim, the chosen ASO size was 2–4 mm larger than the measured ASD diameter. By following this

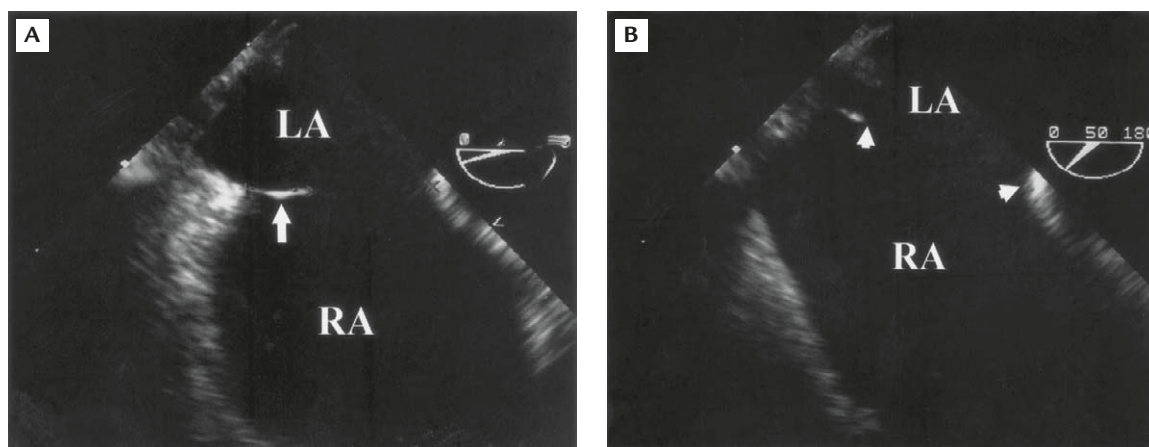


Figure 3. (A) Atrial septal defect with thin interatrial septum (arrow). (B) Atrial septal defect diameter increased to 39 mm (arrowheads) after failed Amplatzer septal occluder implantation. LA = left atrium; RA = right atrium.

strategy, we found that the procedure failure rate, complications and residual shunt were not statistically significantly different between groups A and B during the follow-up period.

There were six patients in this study in whom the procedure failed; two were children and four were adults. In the two pediatric patients (age, 4.7 and 10.1 years; body weight, 18.9 and 31.8 kg), ASD diameter was 24 mm and 26 mm. In both, the ASD was considered large for their age. The reason for failure was due to small left atrial capacity in which the left atrial disc was unable to expand fully. In the light of these two cases, under such circumstances, the ASO was deployed via the pulmonary veins and such large defects in pediatric patients could be successfully closed. In the four adult patients in whom the procedure failed, the reasons for failure were: large ASD and ASO prolapsed into the right atrium in one; very thin interatrial septum that was torn by the ASO while the left atrial disc was pulled from the left atrium into the right atrium, increasing the diameter from 25 mm to 39 mm in one (Figure 3); occluders migrated to the right ventricle in two—one immediately and one on the following day. In the former, the ASD size measured by TEE was 36 mm and the patient had vigorous cough that led to ASO dislodgment immediately after recovery from general anesthesia. Therefore, prevention of severe cough during recovery from general anesthesia is recommended.²⁰ In the latter, the ASD size

measured during the operation was 45 × 25 mm, which was larger than that measured by TEE (34 mm) in the catheterization room, and thus ASO dislodgment was due to the underestimation of ASD size.

The reported complication rate of ASD closure by ASO is relatively low (6.4–7.2%) compared with surgery (24–68.2%).^{14,21} Atrial tachyarrhythmia, complete atrioventricular block, thromboembolism, transient ischemic attack, intravascular hemolysis, atrioventricular valve damage, device migration, perforation of a nearby structure, and even mortality have been reported.^{2,14,18,21–24} In our study, only two patients (2.4%) had transient arrhythmia during the procedure, and both had spontaneous recovery. There were no other complications in the study.

Trivial residual leaks are not uncommon after ASO implantation, but usually diminish during follow-up.⁷ In our series, immediate residual shunt was found in 20 patients (25.6%). During follow-up (range, 1–46 months), persistent small residual shunt was found in five patients (6.4%). Since these patients were asymptomatic, no further treatment was undertaken. Occasionally, the ASO disk may impinge on the aorta and induce perforation, probably due to application of over-sized ASO.²⁵ In our study, the ASO size was equal to or not more than 4 mm larger than the measured ASD diameter. There was no vascular impingement in our cases.

ASD with deficient SA rim is a common variation. Similar to ASD with sufficient rims, transcatheter closure of secundum type ASD is also effective for ASD with SA rim deficiency.

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